Interview Summary	Application No.	Applicant(s)	
	10/686,603	ZORAN, DON	
	Examiner	Art Unit	
	Erica E Cadugan	3722	

All participants (applicant, applicant's representative, PTO personnel):

(1) Erica E Cadugan. (3)_____.

(2) Val Cottrill. (4)_____.

Date of Interview: 5/25/05 & 5/31/05.

Type: a)☒ Telephonic b)☐ Video Conference
c)☐ Personal [copy given to: 1)☐ applicant 2)☐ applicant's representative]

Exhibit shown or demonstration conducted: d)☐ Yes e)☒ No.
If Yes, brief description: _____.

Claim(s) discussed: all pending.

Identification of prior art discussed: none specifically.

Agreement with respect to the claims f)☐ was reached. g)☒ was not reached. h)☐ N/A.

Substance of Interview including description of the general nature of what was agreed to if an agreement was reached, or any other comments: See Continuation Sheet.

(A fuller description, if necessary, and a copy of the amendments which the examiner agreed would render the claims allowable, if available, must be attached. Also, where no copy of the amendments that would render the claims allowable is available, a summary thereof must be attached.)

THE FORMAL WRITTEN REPLY TO THE LAST OFFICE ACTION MUST INCLUDE THE SUBSTANCE OF THE INTERVIEW. (See MPEP Section 713.04). If a reply to the last Office action has already been filed, APPLICANT IS GIVEN ONE MONTH FROM THIS INTERVIEW DATE, OR THE MAILING DATE OF THIS INTERVIEW SUMMARY FORM, WHICHEVER IS LATER, TO FILE A STATEMENT OF THE SUBSTANCE OF THE INTERVIEW. See Summary of Record of Interview requirements on reverse side or on attached sheet.

ERICA CADUGAN
PRIMARY EXAMINER

Examiner Note: You must sign this form unless it is an Attachment to a signed Office action.

Examiner's signature, if required

Summary of Record of Interview Requirements

Manual of Patent Examining Procedure (MPEP), Section 713.04, Substance of Interview Must be Made of Record
A complete written statement as to the substance of any face-to-face, video conference, or telephone interview with regard to an application must be made of record in the application whether or not an agreement with the examiner was reached at the interview.

Title 37 Code of Federal Regulations (CFR) § 1.133 Interviews
Paragraph (b)
In every instance where reconsideration is requested in view of an interview with an examiner, a complete written statement of the reasons presented at the interview as warranting favorable action must be filed by the applicant. An interview does not remove the necessity for reply to Office action as specified in §§ 1.111, 1.135. (35 U.S.C. 132)

37 CFR §1.2 Business to be transacted in writing.
All business with the Patent or Trademark Office should be transacted in writing. The personal attendance of applicants or their attorneys or agents at the Patent and Trademark Office is unnecessary. The action of the Patent and Trademark Office will be based exclusively on the written record in the Office. No attention will be paid to any alleged oral promise, stipulation, or understanding in relation to which there is disagreement or doubt.

The action of the Patent and Trademark Office cannot be based exclusively on the written record in the Office if that record is itself incomplete through the failure to record the substance of interviews.

It is the responsibility of the applicant or the attorney or agent to make the substance of an interview of record in the application file, unless the examiner indicates he or she will do so. It is the examiner's responsibility to see that such a record is made and to correct material inaccuracies which bear directly on the question of patentability.

Examiners must complete an Interview Summary Form for each interview held where a matter of substance has been discussed during the interview by checking the appropriate boxes and filling in the blanks. Discussions regarding only procedural matters, directed solely to restriction requirements for which interview recordation is otherwise provided for in Section 812.01 of the Manual of Patent Examining Procedure, or pointing out typographical errors or unreadable script in Office actions or the like, are excluded from the interview recordation procedures below. Where the substance of an interview is completely recorded in an Examiners Amendment, no separate Interview Summary Record is required.

The Interview Summary Form shall be given an appropriate Paper No., placed in the right hand portion of the file, and listed on the "Contents" section of the file wrapper. In a personal interview, a duplicate of the Form is given to the applicant (or attorney or agent) at the conclusion of the interview. In the case of a telephone or video-conference interview, the copy is mailed to the applicant's correspondence address either with or prior to the next official communication. If additional correspondence from the examiner is not likely before an allowance or if other circumstances dictate, the Form should be mailed promptly after the interview rather than with the next official communication.

The Form provides for recordation of the following information:

- Application Number (Series Code and Serial Number)
- Name of applicant
- Name of examiner
- Date of interview
- Type of interview (telephonic, video-conference, or personal)
- Name of participant(s) (applicant, attorney or agent, examiner, other PTO personnel, etc.)
- An indication whether or not an exhibit was shown or a demonstration conducted
- An identification of the specific prior art discussed
- An indication whether an agreement was reached and if so, a description of the general nature of the agreement (may be by attachment of a copy of amendments or claims agreed as being allowable). Note: Agreement as to allowability is tentative and does not restrict further action by the examiner to the contrary.
- The signature of the examiner who conducted the interview (if Form is not an attachment to a signed Office action)

It is desirable that the examiner orally remind the applicant of his or her obligation to record the substance of the interview of each case. It should be noted, however, that the Interview Summary Form will not normally be considered a complete and proper recordation of the interview unless it includes, or is supplemented by the applicant or the examiner to include, all of the applicable items required below concerning the substance of the interview.

A complete and proper recordation of the substance of any interview should include at least the following applicable items:

1) A brief description of the nature of any exhibit shown or any demonstration conducted,
2) an identification of the claims discussed,
3) an identification of the specific prior art discussed,
4) an identification of the principal proposed amendments of a substantive nature discussed, unless these are already described on the Interview Summary Form completed by the Examiner,
5) a brief identification of the general thrust of the principal arguments presented to the examiner,
   (The identification of arguments need not be lengthy or elaborate. A verbatim or highly detailed description of the arguments is not required. The identification of the arguments is sufficient if the general nature or thrust of the principal arguments made to the examiner can be understood in the context of the application file. Of course, the applicant may desire to emphasize and fully describe those arguments which he or she feels were or might be persuasive to the examiner.)
6) a general indication of any other pertinent matters discussed, and
7) if appropriate, the general results or outcome of the interview unless already described in the Interview Summary Form completed by the examiner.

Examiners are expected to carefully review the applicant's record of the substance of an interview. If the record is not complete and accurate, the examiner will give the applicant an extendable one month time period to correct the record.

Examiner to Check for Accuracy

If the claims are allowable for other reasons of record, the examiner should send a letter setting forth the examiner's version of the statement attributed to him or her. If the record is complete and accurate, the examiner should place the indication, "Interview Record OK" on the paper recording the substance of the interview along with the date and the examiner's initials.

Continuation of Substance of Interview including description of the general nature of what was agreed to if an agreement was reached, or any other comments: Applicant faxed the attached proposed response to the final rejection. Examiner reviewed the proposed response, and indicated that if such were filed in the present after-final situation, the Examiner would send out an advisory action indicating that the proposed amendment would not be entered because it raises new issues that would require further search and/or consideration (note specifically the new issues created by adding limitations re the sheets having holes, etc., for example)..

★ ATTACHMENT TO INTERVIEW SUMMARY★

Gowling Lafleur Henderson LLP | Barristers & Solicitors | Patent & Trade Mark Agents |

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To:	Erica Cadugan		
Company:	USPTO	City/Country:	
Fax Number:	571-273-4474	Phone Number:	571-272-4474

Date:	May 25, 2005
Re:	United States Patent Application No. 10/686,603 Apparatus and Method for Damping Vibration in a Machine Tool
Total Pages:	27 (including cover)
File Number:	K8000275US
CopyTrak #:	010

If there is a problem with transmission or all pages are not received, please call Krista Heer at (519) 576-6910 Ext. 77232 for retransmission.

WAT_LAW\ 175087\1

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

REQUEST FOR INTERVIEW

Application No.:	10/686,603
Title:	Apparatus and Mehtod for Damping Vibration in a Machine Tool
Inventor:	Don Zoran
Applicant:	Racer Machinery International Inc.
Filing Date:	October 17, 2003
Examiner:	Erica E. Cadugan
Group Art Unit:	3722
Our File No.:	K8000275US

Commissioner of Patents
U.S. Patent and Trademark Office
Customer Service Window
Randolph Building
401 Dulany Street
Alexandria, VA 22314
U.S.A.

Dear Commissioner:

The Applicant requests a telephone interview with the Examiner. The purpose of the interview would be to discuss the proposed amendments to the claims which are enclosed, which proposed amendments have been prepared in view of the office action mailed on April 13, 2005. Also, a declaration under 37 C.F.R. §1.132 is enclosed for discussion in the telephone interview, if granted.

The Applicant proposes that claims 4, 13, 18, 21, and 22 be amended by including limitations primarily relating to the manner in which constituent parts are fastened together with a sheet of damping material between the constituent parts. The Applicant also proposes that claim 6 be amended by including limitations relating to the thickness of the damping material. In the enclosed revised claims, the references in square brackets to paragraphs are provided to show where, in the specification, support can be found for an amendment. The amendments are believed to patentably distinguish the claims in

question over the prior art reference cited in the outstanding office action herein, namely, U.S. patent application publication no. 2002/0081956 (Bennett et al.).

In the office action, claims 9, 17, and 20 were rejected on the ground that they were considered to be obvious in view of the Bennett et al. reference. The enclosed declaration is submitted as evidence that the Bennett et al. reference is reasonably pertinent to the particular problem with which the inventor herein, Mr. Zoran, was concerned.

It is hoped that the telephone interview with the Examiner could take place on Thursday, May 26 or on the morning of Friday, May 27. The Applicant respectfully requests that the Examiner advise the Applicant of a date and time when the Examiner would be available for a telephone interview, if granted.

Respectfully submitted,
RACER MACHINERY INTERNATIONAL INC.

V. Cottrill

Per: Valentine A. Cottrill
Agent for the Applicant
Reg. No. 50,187

Date: May 25, 2005

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Fax: (519) 571-5009

WAT_LAW\ 175014\1

CLAIMS:

1. (Canceled)

2. (Canceled)

3. (Canceled)

4. (Currently Amended)

A machine tool for performing a machine tool function including a plurality of components adapted to cooperate with each other to execute the machine tool function, the machine tool having:

a plurality of constituent parts, each ~~side~~said constituent part being substantially rigid;

a plurality of sheets of damping material;

each said sheet having at least one hole formed therein [para. 0029];

each said component comprising at least two of said constituent parts and at least one of said sheets, said at least one sheet being interposed between said at least two constituent parts, to prevent the constituent parts from contacting each other [para. 0025];

each said constituent part including at least one first surface adapted to cooperate with at least one second surface on an adjacent constituent part to define a slot in which said at least one sheet is receivable, said at least one sheet being interposed between said at least one first surface and said at least one second surface to form each said component;

each said sheet being substantially planar and substantially non-resilient; and

each ~~said sheet being substantially non-resilient, such that each said component is rigid and substantially non-resilient~~of said at least two constituent parts having at least one hole drilled therein respectively, each said at least one hole in each said constituent part being substantially

aligned with said at least one hole in said at least one sheet to receive a bolt for fastening said at least two constituent parts together with said at least one sheet positioned therebetween, to form each said component [para. 0029],

whereby vibration of the machine tool while performing the machine tool function is ~~limited~~damped by said sheets of damping material and the machine tool has the stiffness required for executing said machine tool function.

5. (Previously Presented)

A machine tool according to claim 4 in which each said sheet is substantially impermeable.

6. (Currently Amended)

A machine tool according to claim 5 in which each said sheet comprises polyvinylchloride and each said sheet has a thickness between approximately 0.01 inch and approximately 0.02 inch [para. 0029].

7. (Canceled)

8. (Canceled)

9. (Previously Presented)

A machine tool according to claim 4 in which each said constituent part comprises machined steel.

10. (Canceled)

11. (Canceled)

12. (Canceled)

13. (Currently Amended)

A machine tool for performing a machine tool function including a plurality of components adapted to cooperate with each other to execute the machine tool function, the machine tool having:

a plurality of constituent parts, each said constituent part being substantially rigid;

a plurality of linings for damping vibration of the machine tool during performance of the machine tool function, each said lining being substantially planar;

each said component comprising at least two of said constituent parts and at least one of said linings sandwiched therebetween, to prevent the constituent parts from contacting each other [para. 0025];

each said lining being substantially non-resilient and having a thickness between approximately 0.01 inch and approximately 0.02 inch [para. 0019];

each said lining having at least one hole formed therein [para. 0029];

one of said at least two constituent parts having at least one first mating surface adapted to cooperate with at least one second mating surface of the other of said at least two constituent parts to define a slot for receiving said at least one lining, said at least one lining being configured to maintain contact with said at least one first mating surface and with said at least one second mating surface when said at least one lining is positioned therebetween such that vibration of the machine tool during performance of the machine tool function is damped by said at least one lining; and

each ~~said lining being substantially non-resilient, such that~~of said at least two constituent parts having at least one hole drilled therein, each said at least one hole being substantially aligned with said at least one hole in said lining to receive a bolt for fastening said at least two constituent parts together with said lining positioned therebetween [para. 0029] to form each said component ~~is rigid and substantially non-resilient~~,

whereby ~~each said component has a predetermined stiffness and~~ vibration of the machine tool is ~~limited~~damped by said linings in said components, and the machine tool has the stiffness required for executing said machine tool function.

14. (Previously Presented)
A machine tool according to claim 13 in which each said lining is substantially impermeable.

15. (Previously Presented)
A machine tool according to claim 14 in which each said lining comprises polyvinylchloride.

16. (Canceled)

17. (Previously Presented)
A machine tool according to claim 13 in which each said constituent part comprises machined steel.

18. (Currently Amended)
A method of damping vibration of a machine tool, the machine tool being adapted to perform a machine tool function and including a plurality of machine tool components adapted to cooperate with each other to execute the machine tool function, the method comprising the steps of:

(a) providing at least two constituent parts for each said component, each said constituent part being substantially rigid, each said constituent part having at least one hole drilled therein [para. 0029];

(b) providing at least one sheet of damping material for each said component, said at least one sheet of damping material having a thickness between approximately 0.01 inch and approximately 0.02 inch and having at least one hole formed therein [para. 0029];

(c) forming each said component by interposing said at least one sheet of damping material between said at least two constituent parts, said at least

one sheet of damping material being substantially non-resilient, ~~such that each said component has a predetermined stiffness~~said at least one hole in said at least one sheet of damping material being substantially aligned with said holes drilled in said at least two constituent parts [para. 0029]; and

~~(d) assembling said components to form the machine tool,~~

(d) inserting a bolt into said at least one hole in said at least one sheet of damping material and said holes drilled in said at least two constituent parts to fasten said at least two constituent parts together with said at least one sheet of damping material positioned therebetween [para. 0029] to form each said component,

whereby said at least one sheet of damping material dampens vibration of the machine tool during performance thereby of the machine tool function.

19. (Previously Presented)

A method according to claim 18 in which each said sheet of damping material comprises polyvinylchloride.

20. (Previously Presented)

A method according to claim 18 in which each said constituent part comprises machined steel.

21. (Currently Amended)

In a machine tool adapted for performing a machine tool function, the machine tool including a plurality of components adapted for cooperation with each other to execute the machine tool function, the improvement comprising each said component including at least two constituent parts, each said constituent part being substantially rigid, one of said at least two constituent parts having at least one first surface and the other of said at least two constituent parts having at least one second surface positioned parallel to said at least one first surface to define an aperture therebetween, and at least one sheet of damping material receivable in the aperture between said at least one first surface and said at least one second

surface to be sandwiched therebetween~~,~~ for dampening vibration of the machine tool, said at least one sheet being substantially non-resilient, ~~each said component being rigid and substantially non-resilient~~said at least one sheet having at least one hole formed therein [para. 0029], each of said at least two constituent parts having at least one hole drilled therein respectively, each said hole in said at least two constituent parts being substantially aligned with said at least one hole in said at least one sheet of damping material to receive a bolt for fastening said at least two constituent parts together with said at least one sheet positioned therebetween [para. 0029] to form each said component.

22. (Currently Amended)

A component to be included in a machine tool, said component having predetermined dimensions, the component including:

at least two constituent parts, each said constituent part being formed of substantially rigid material;

at least one sheet of damping material, said at least one sheet of damping material being substantially non-resilient;

said at least two constituent parts cooperating with each other to form at least one slot in which said at least one sheet is receivable;

said at least one sheet ~~separated~~separating each of said at least two constituent parts from each other to limit vibration of the machine tool;

said at least one sheet of damping material having a thickness between approximately 0.01 inch and approximately 0.02 inch and having at least one hole formed therein [para. 0029]; and

each of said at least two constituent parts having at least one hole drilled therein respectively [para. 0029]; and

each said hole in said at least two constituent parts being substantially aligned with said at least one hole in said at least one sheet of damping material to receive a bolt for fastening said at least two constituent parts together with said at least one sheet of damping material positioned therebetween [para. 0029] to form each said component.

WAT_LAW\ 173770\1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In Re the Application of:

Zoran

Serial No.:	10/686,603
Filed:	October 17, 2003
For:	Apparatus and Method for Damping Vibration in a Machine Tool
Examiner:	Erica E. Cadugan
Art Unit:	3722
Our File:	K8000275US

May 24, 2005

DECLARATION OF DON ZORAN UNDER 37 C.F.R. §1.132

Commissioner of Patents
U.S. Patent and Trademark Office
Customer Service Window
Randolph Building
401 Dulany Street
Alexandria, VA 22314
U.S.A.

Dear Commissioner:

I, DON ZORAN, hereby declare that:

1. I have used and constructed machine tools throughout my career, beginning in 1975. I became a Certified Machine Tools Sales Engineer in July, 2001. I have been

employed in connection with machine tools, both as a tool and die maker, and also in building, servicing and selling machine tools since 1975.

2. I am the inventor of the invention disclosed in the above-identified application and therefore I am familiar with the invention described in the above-identified application and have reviewed the Office Action dated April 13, 2005 together with the reference cited therein. I make this Declaration in support of the arguments to be made in the Applicant's response to the office action which are that Bennett et al. does not teach, suggest or render obvious the invention as presently claimed.

3. A machine tool is defined as follows (Academic Press Dictionary of Science and Technology, 1992):

> Any stationary power-driven machine designed primarily for shaping and sizing metal parts.

As indicated in the Background of the above-identified application, "known machine tools typically produce a great deal of vibration when operating" (para. 0003). When operating, the machine tool is performing a machine tool function, which is defined in the application as including one or more material removal processes (para. 0001). Typical material removal processes which are performed by machine tools are described in paragraph 0001 of the application as follows:

> turning, boring, drilling, reaming, threading, milling, shaping, planing, and broaching.

In order to perform a machine tool function, therefore, the workpiece must be subjected to very high stress, because the workpiece is metal. For example, a typical modulus of elasticity for steel is approximately 30 x 10^6 psi, and a typical modulus of elasticity for aluminum is about 10-11 x 10^6 psi (Smith, The Science of Engineering Materials (2^{nd} ed.,

1977)). Machine tools typically produce a substantial amount of vibration because of the relatively large amounts of stress to which the workpiece must be subjected in order to remove material therefrom. In addition, and as known in the art, the material removal process must be performed to a relatively high degree of accuracy, notwithstanding the very large stresses to which the workpiece is subjected. For example, a machine tool typically is required to produce a part within 0.001", and can be required to meet a tolerance of as little as 0.0001".

4. The high vibration level which typically accompanies material removal processes in machine tools are undesirable because of three consequences of the vibration:

(a) the tool performing the material removal process is vibrated, adversely affecting the accuracy to which the material removal process is performed;

(b) the vibration resulting from the material removal process causes excessive noise to be generated, affecting the health and safety of the workers; and

(c) the vibration can, ultimately, destroy the machine tool itself.

5. Although the Applicant is a person skilled in the art, it took many years of research to develop a machine tool which would operate with substantially reduced vibration, and a method for making such a machine tool. To do this, the machine tool must have sufficient vibration-reducing capabilities to achieve the desired reduction in vibration but have sufficient stiffness to perform material removal processes within the required tolerances.

6. Bennett et al. is cited in the office action dated April 13, 2005 (at p. 5) as teaching "all aspects of the present invention", except that the constituent parts are made of machined steel. However, Bennett et al. describes a device to be used for chemical mechanical polishing. Chemical mechanical polishing is described in U.S. Patent No. 5,897,426 (Somekh), at col. 1, lines 21-35, as "one accepted method of planarization" used in the manufacture of integrated circuits. Based on a paper (attached) in which chemical mechanical polishing is described, it is my understanding that this process involves downward pressure of about 4-10 psi on a silicon workpiece. Therefore, the stresses to

which a workpiece is subjected in chemical mechanical polishing are very small, unlike the stresses which a machine tool must be able to withstand without affecting accuracy.

? no cl. lang to distinguish

7. Bennett et al. thus discloses a solution to a problem which is very different from the problem which the invention herein was invented to address.

8. I have been continuously engaged in the design and manufacture of machine tools since 1975. As a skilled person in the art of machine tool manufacture for 30 years, I note that the need for a machine tool which operates with substantially less vibration has been long recognized. The Applicant's design is estimated to reduce noise levels by about 15% to 20%.

9. As indicated in paragraphs 0004-0005 of the application, the prior art indicates that using monolithic castings to form components of machine tools are preferable, the idea being that vibration is more efficiently dissipated in a larger mass. The prior art thus teaches away from the invention. However, castings have a number of disadvantages when compared to the invention, in which components are made up of machined steel constituent parts with damping material therebetween.

10. Although only recently introduced to the market, the apparatus of the invention has achieved a significant degree of commercial interest. Starting after October 17, 2003, and without advertising (except through one-on-one discussions), five units embodying the Applicant's design herein have been sold.

11. The applicant has provided an economically feasible solution permitting operation of machine tools with much reduced vibration. To my knowledge, there is not another machine tool on the market that can meet the specifications and economic feasibility of machine tools produced by the process and apparatus of the present invention. Applicant's process and apparatus finally provide an inexpensive and reliable solution to resolve a long-felt need, thus providing evidence of the novelty and unobviousness of the presently claimed method.

12. I hereby declare that all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true; and further, that these statements were made with the knowledge that wilful, false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such wilful false statements may jeopardize the validity of the application or any patent issuing thereon.

Signed at Cambridge, Ontario and dated this 24 of May, 2005.

DON ZORAN

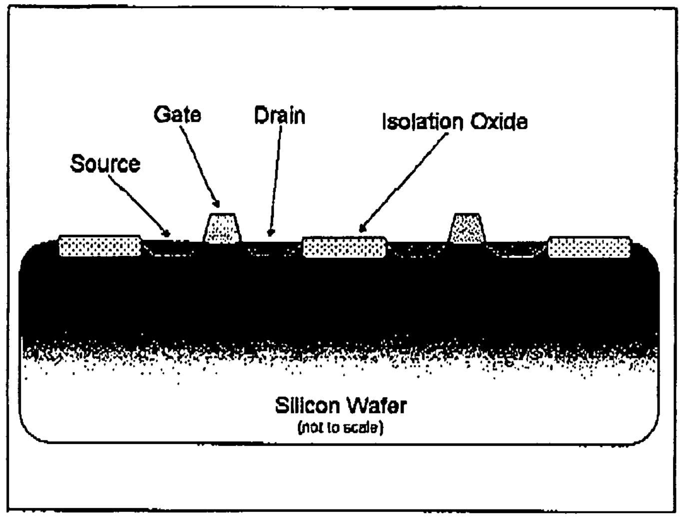
WAT_LAW\ 1735285\5

Chemical Mechanical Polishing (CMP)

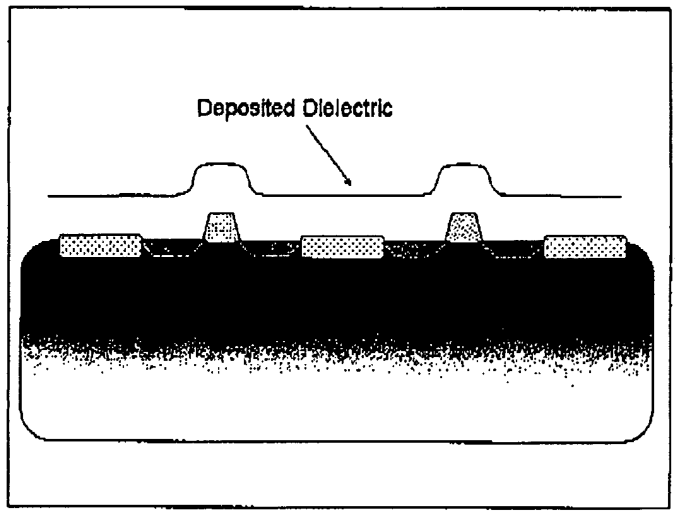
This document is intended to introduce the techniques of Chemical Mechanical Polishing (CMP) to the new user so that they may be better prepared to integrate CMP into their process flow. CMP can be used for many different purposes but it is limited in what it can do and what substrates it can handle. If after reading through this document you still have questions regarding what can be done here at the CNF, please contact the staff member in charge of the tool.

History

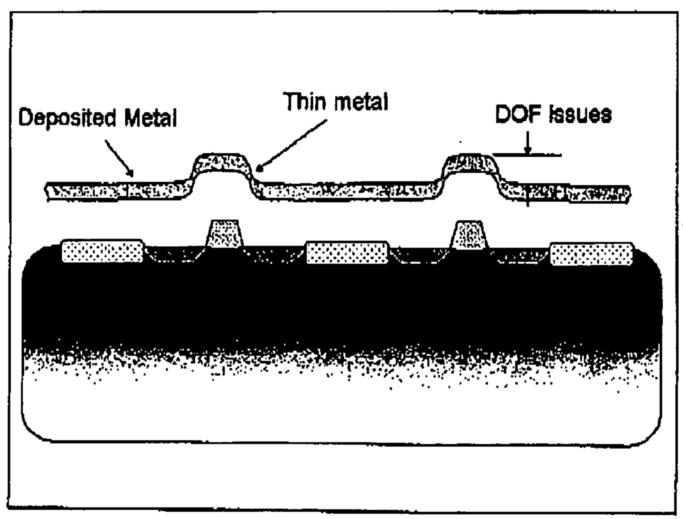
IBM invented CMP in the late 80's to allow for more metal layers in the integrated circuits (IC) that they produced. Originally it was called Chemical Mechanical Planarization (CMP) since that was the purpose for which it was created. A typical transistor wiring process flow of the time is shown.



After creating the transistors in the silicon, a dielectric (typically silicon oxide) was deposited. The deposited material replicates the step height of the underlying surface and in some cases can actually increase the topology. When the metal is deposited to form the first wiring level, the metal thickness can significant thin over the edges of the feature. This causes a reduction in the wire cross-section and a subsequent increase in the wire resistivity.

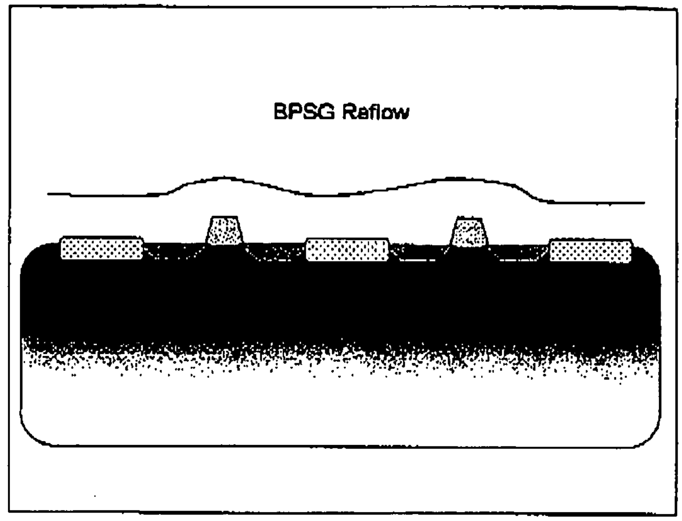


Additionally, the step height causes problems when trying to do high-resolution lithography. Pushing optical lithography tools to print ever-smaller features requires moving toward high numerical aperture (NA) tools. These tools can print smaller features at the expense of a smaller depth-of-focus (DOF) window. This requires that the surface height of the film they are patterning to be within a narrow range for the image to print accurately. Any topology in the surface makes it difficult to focus the image on both the high and low areas.

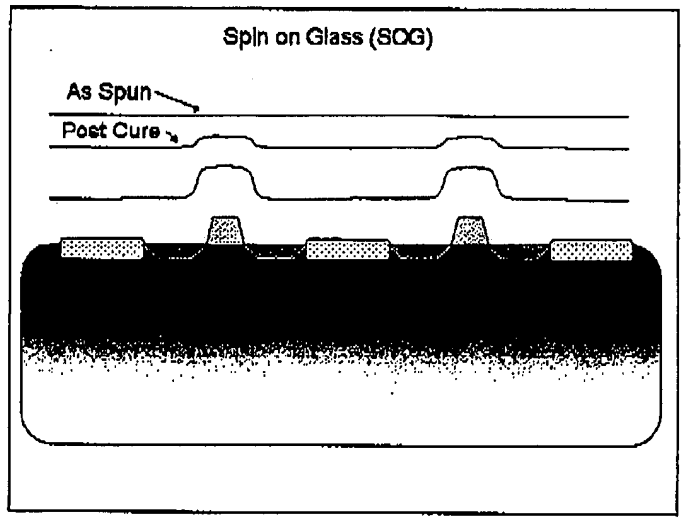


Other Planarization Techniques

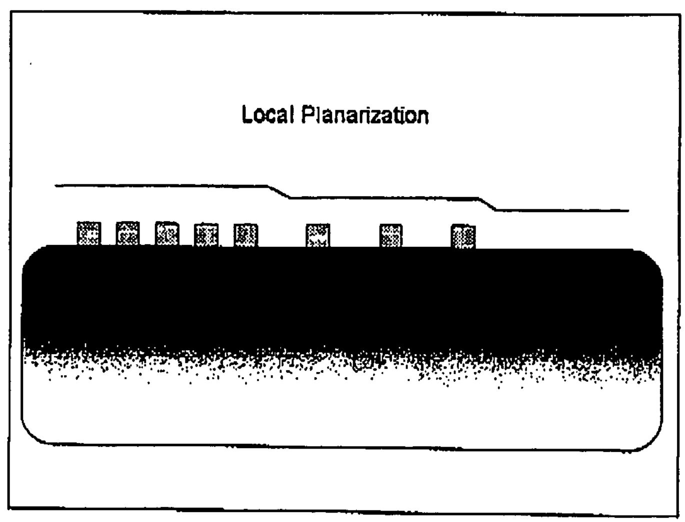
To remove step heights in the dielectric, IC companies used a variety of techniques prior to CMP. One technique was to deposit a silicon oxide layer heavily doped with boron and phosphorus, (Boron-Doped Phosphosilicate Glass-BPSG). This material has a lower melting point than undoped silicon oxide. A high temperature anneal was performed and the material would reflow slightly and smooth out the step heights.



An alternate strategy was to use a Spin on Glass (SOG) material. This is a liquid silicon oxide organic precursor that is spun on the wafer in a manner similar to photoresist. Being liquid, the material planarizes the surface before the solvent is baked off. After it is spun on, the material undergoes a high temperature curing process. During this cure, most of the organic constituents are driven off and the material shrinks to form a type of silicon oxide dielectric. The main issues with this type of process is that the quality of the oxide is very poor compared to a thermal oxide, and it does not completely remove the step height due to differences in the total film shrinkage between thick and thin areas.



Many other techniques were utilized as well but all of them suffered from various drawbacks. The main problem with even the best techniques was that they only achieved local planarization. There was still a height variation between areas of the chips that had different pattern densities. This caused depth of focus problems with the lithography steps.

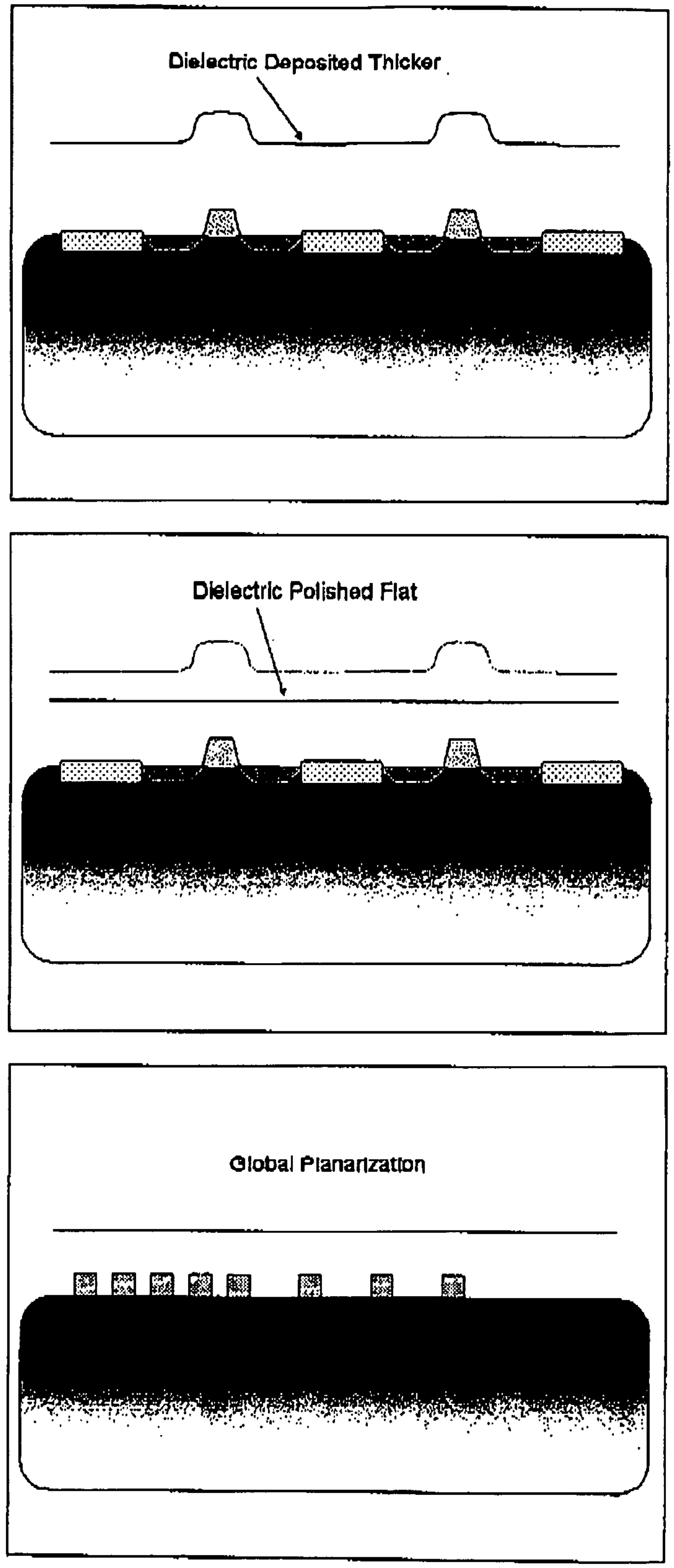


CMP Planarization

CMP improved on the alternate planarization techniques in many ways. The basic process is to deposit the silicon oxide thicker than the final thickness you want and polish the material back until the step heights are removed. This gives you a good flat surface for the next level. In addition, the process can be repeated for every level of wiring that is added.

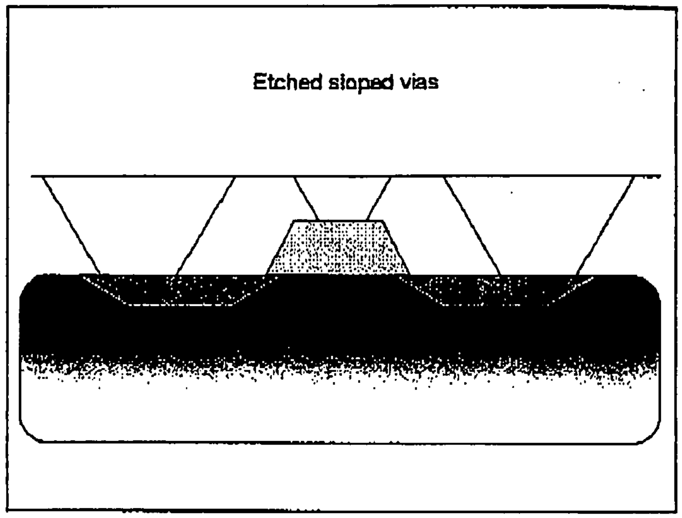
CMP is the only technique that performs global planarization of the wafer. This is absolutely required to increase the number of wiring levels in the integrated circuits. Prior to CMP, DOF issues due to global planarization problems limited the total number of IC wiring levels to 3 – 4. With CMP, current state of the art IC production is able to achieve 7 – 8 wiring levels.

These achievements did not come without any cost. Many companies were hesitant to integrate CMP for several different reasons. One is that the process suffers from defect issues due to scratching of the wafer surface and from problems removing the abrasive particles when the polishing is finished. In addition, early CMP suffered from being a bit more of an art than a science. The polishing process was not well understood and variations in the material used to perform the polishing caused process shifts that were hard to correct. As the process has matured, many of those issues have been resolved and CMP is now viewed as a more accepted IC processing technology.

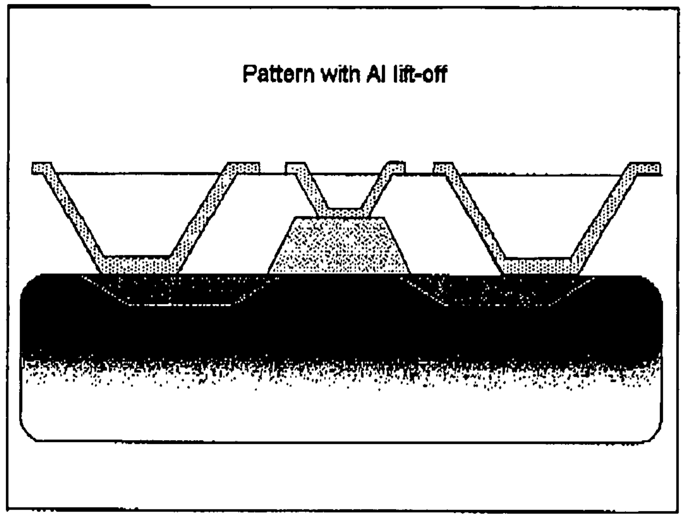


Damascene CMP

An alternate use for the CMP process was for creating inlaid metal patterns on the wafer for the wiring levels. This is called a damascene process. It was used to replace the traditional method of making electrical contacts between the IC wiring levels.



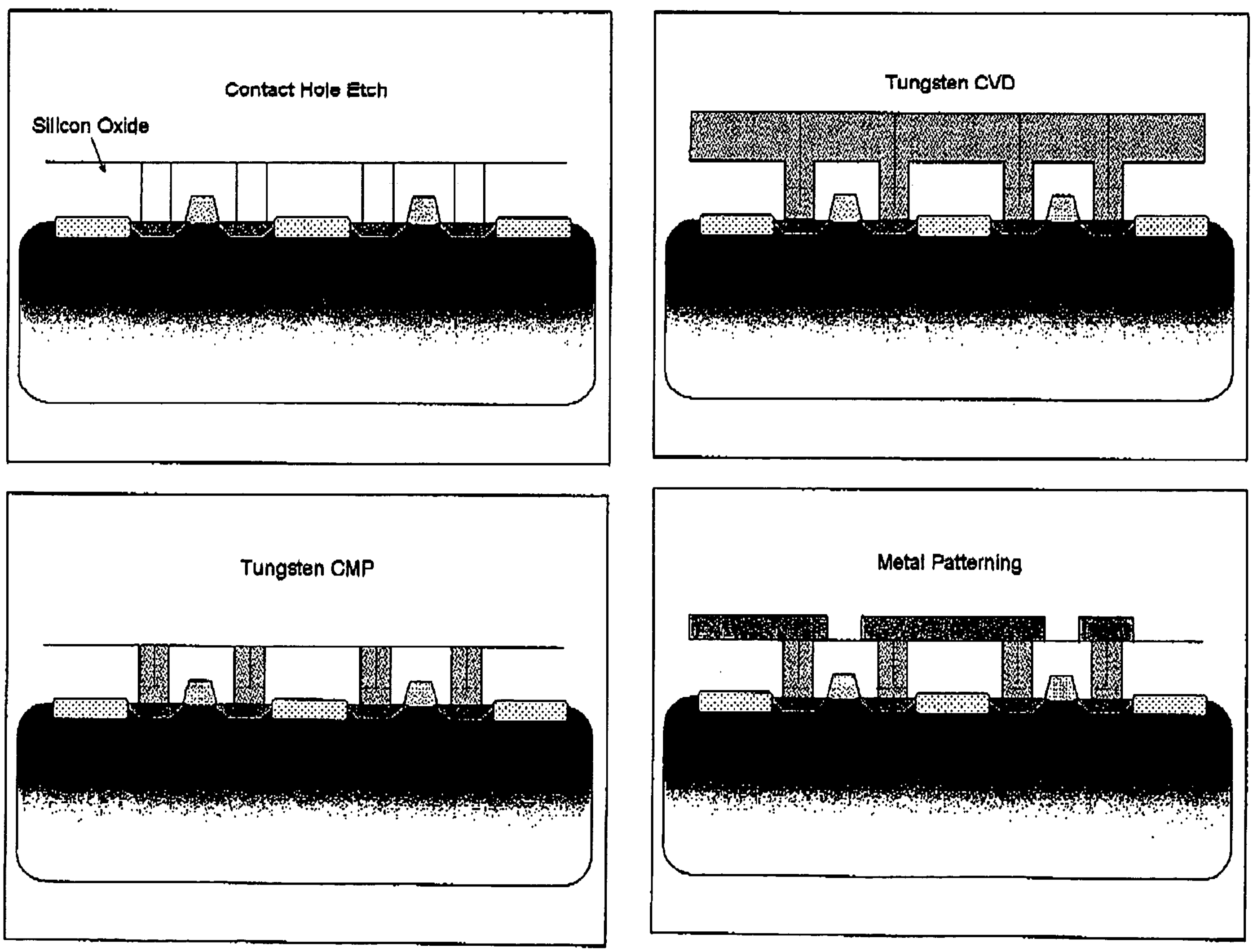
Traditionally to contact the source, drain, and gates of the transistors, large sloped holes or vias were etched into the dielectric, and the wiring metal was patterned over the hole and allowed to contact the lower level directly. The main detractor with this process is the amount of lateral space each contact took up, preventing high-density packing of the transistors.



The tungsten damascene process starts with a fully planarized dielectric surface that is patterned with vertical contact holes. These holes can be made much smaller and spaced tighter than the sloped vias of the previous process. Tungsten (W) is then deposited using a chemical vapor deposition process to produce a uniform coating thickness on all exposed parts of the wafer. In this two phase process, the tungsten precursor (WF_6) migrates to the wafer surface where is decomposes into solid tungsten and a volatile by-product. The CVD process 'grows' a crystalline tungsten film that fills the holes from all sides, producing a hole that is completely filled with metal, leaving only a very narrow seam down the middle of the contact hole. Usually a barrier / adhesion layer is put down first (not shown) to reduce electrical resistance to the underlying metal and protect it from the corrosive W CVD chemistry. A CMP process is then

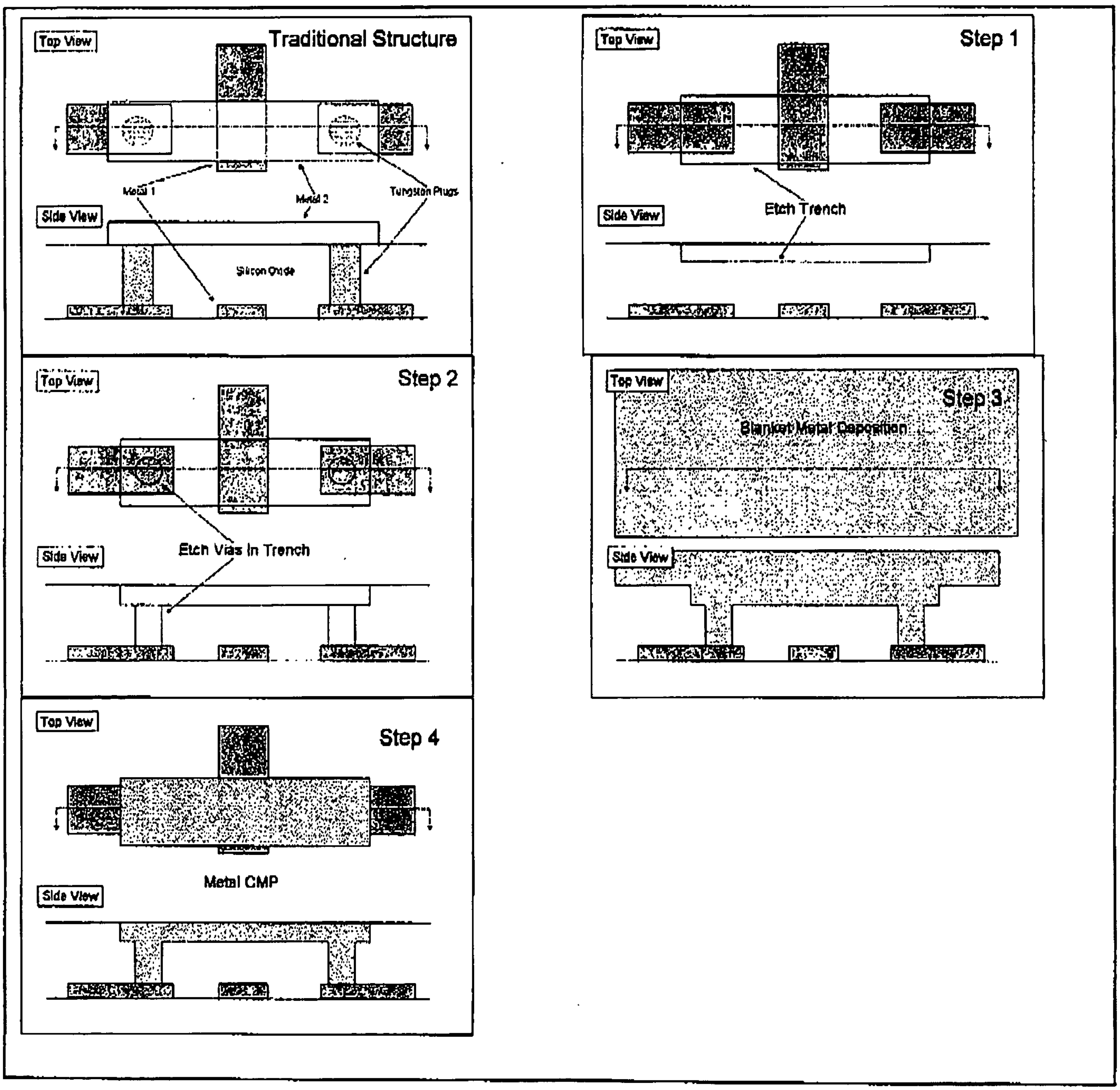
employed to remove the surface tungsten, leaving behind the filled contact holes. This polishing process is designed to be highly selective in removing the tungsten versus the underlying dielectric. This allows the process to use the dielectric as a stopping layer, improving the process latitude. Finally a metal layer is patterned on top of the filled contacts to complete the circuit. This process is repeated with the oxide planarization step to add each wiring level to an IC.

Instead of just being used to pattern vias for connecting two wiring levels, the damascene process can be used with trenches patterned in the dielectric to form the wiring themselves. In this process, a shallow trench is etched in the dielectric in the shape of the desired wire, the metal is deposited on the wafer, and the CMP process selectively removes the material to leave the trench filled. This process is one of the key technologies that has enabled the integration of copper into IC wiring levels. Prior to this, there was no way to easily pattern small copper features since copper cannot be plasma etched. The damascene process is also utilized in the Shallow Trench Isolation (STI) scheme to further permit tighter transistor packing.



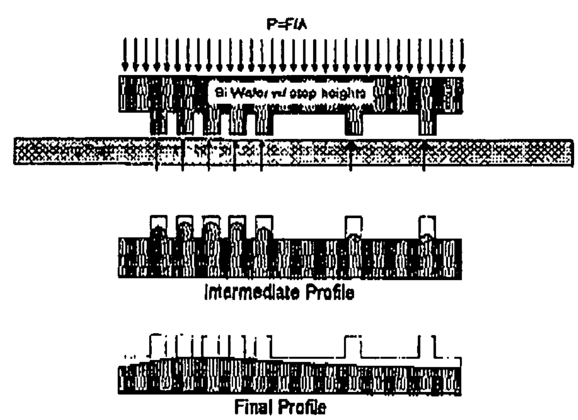
Dual Damascene CMP

In the dual damascene process, both the wiring level and the interlevel connections are created with a single polishing step. Two patterning steps are used to create features of two different depths. Blanket metal is deposited and a single CMP step is used to create the inlaid structure. This is the current process used by many IC companies to integrate copper into their circuits.



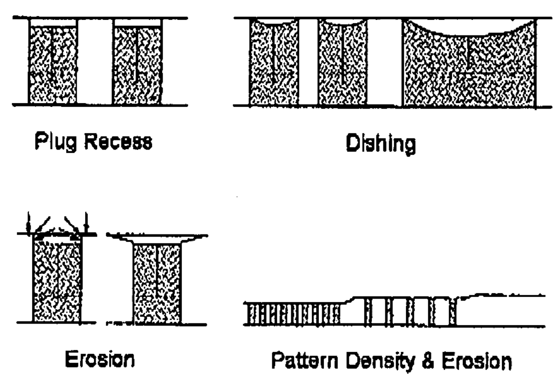
CMP Pattern Density Issues

CMP is seen by most of the semiconductor industry as critical for producing 0.35um devices and smaller, although it does suffer from some problems that need to be accounted for during the process integration. When polishing a wafer that has step features, only the top of the features touch the polishing pad, concentrating the pressure on these contact points. This increases the polishing rate above that of a blanket wafer. In addition, it causes nonuniformity in the removal rate across patterns of different densities due to variations in the pressure distribution across the pattern.



This pattern density effect on removal rate can cause problems if you have very dense and very sparse pattern in your design. Some ways to account for this is to create dummy shapes around the sparse pattern to try and match the higher pattern density.

The damascene process also suffers from several different issues. One issue is that the material being removed usually has a faster etch rate than the material the structure is inlaid in. This can cause two similar problems called plug recess and dishing. Plug recess is where the damascene structure sits slightly lower than the field area due to the faster removal rate than the field. Due to the mechanical limitation on how much the pad can deform, it is usually not excessive. In general, higher chemically active slurries will have a higher amount of recess due to the wet etching action of the slurry.



Dishing occurs when the polishing pad under the pressure of polishing, is able to deform into the damascene structure and polish it below the field area. The amount of dishing that occurs is related to the polishing pad characteristics, the size of the structure, and the polishing parameters (speed, pressure, temperature).

Erosion of the field material can also occur due to the enhanced polishing at the edges of the structures. As the damascene structure gets recessed, the corners of the field area are exposed and erode more rapidly than the unpatterned areas. This affects the local field material polishing rate and can lead to a variation in the field thickness based on the damascene pattern density. The polishing variables can be tuned to reduce this effect but usually at the expense of other parameters (removal rate, uniformity, etc.).

Glossary

Back pressure – During the polishing process, the wafer is held in place on the carrier head by the retaining ring without vacuum assistance. During polishing, air may be blown out the holes in the backing plate to affect the uniformity of the removal rate. This blowing of air is generally measured in pounds per square inch (psi). Nominal values for the back pressure are from 0 – 2 psi. If you set the back pressure too high it will blow the wafer out of the pocket.

Backing film – a cushioning polymer film attached to the backing plate with a pressure sensitive adhesive. It cushions the wafer during the polishing and compensates for slight flatness variations in the wafer or backing plate. The quality of the backing film is important to prevent uneven polishing.

Backing plate – Located in the carrier head, the backing plate is a precision flat stainless steel disk slightly larger than the wafer. It presses against the back of the wafer and transfers the polishing force to the wafer during CMP. Attached to the backing plate between the plate and the wafer is the backing film. There are many small holes in the backing plate to allow the tool to apply vacuum on the back of the wafer to transport it from the load station to the polishing pad. Vacuum is not generally applied during the polishing process.

Brushcleaner – a tool used to clean and dry wafers after CMP.

Carrier head – Tool fixture that holds the wafer against the polishing pad during the polishing operation. The carrier head is specific for the wafer you are polishing. The CNF has carrier heads for 3", 4", and 6" wafers.

CMP – chemical mechanical polishing, or chemical mechanical planarization. Polishing process utilizing both chemical etching and mechanical removal for nanofabrication.

Conditioning profile – varying the pad conditioning parameters over the polishing pad to affect the polishing uniformity. The Strasbaugh 6EC breaks the conditioning arm sweep into 10 zones in which you can set both the conditioning down force and dwell time for each zone. This allows you to alter the pad characteristics across the wafer track to make improvements in the removal rate uniformity.

Damascene process – CMP process in which a feature is etched in to an already planar film. The features are typically trenches or holes. A second material is then deposited on the wafer filling the feature. The CMP tool is then used to selectively remove the deposited film in the field area, leaving behind the filled feature flush with the planar film.

Diamond disk – a metal disk with embedded industrial diamond particles for conditioning the pad.

Dishing – the thinning of damascene structures below the field area due to pad deformation. Dishing is related to the structure size, pad hardness, and other polishing parameters. See also recess.

Down force – the pressure applied to the wafer during the polishing process. It is expressed in pounds per square inch (psi) with common pressures in CMP being 4 – 10 psi. Below 4 psi the wafer predominantly hydroplanes over the polishing pad and above 10 psi you risk breaking the wafer. The polishing pressure used has a large effect on uniformity and planarization.

Dual damascene – combining etched structures of different heights to fabricate both wiring and interconnects in one damascene polishing process

Erosion – thinning of the field area around damascene structures due to enhanced polishing at the feature edges. The more feature edges you have in a given area, the higher the erosion rate. Erosion issues almost always makes the actual selectivity of a given process lower than that measured on nonpatterned wafers.

Extension – the amount that the top surface of the wafer sits above the retaining ring in the carrier head. If the extension is too low, the etch rate will be reduced on the wafer edge and additionally, the retaining ring will wear down. If the extension is too high the wafer will slip out of the pocket and break during the polishing. Usually measured in mils (thousandths of an inch ≈ 25 microns). The opposite of wafer capture.

Fixed abrasive pads – pads with the abrasive component embedded into it instead of in the slurry. It is used with a chemical only liquid to perform CMP. Recent development in CMP that supposedly gives excellent selectivity.

Microscratching – micro scale scratching caused by debris on the polishing pad, agglomerated slurry particles, and pad defects. These are very hard to prevent from occurring but steps can be taken post polishing to minimize impact.

Pad conditioning – surface treatment of the polishing pad to improve removal rate stability. Hard polishing pads will glaze over from use during polishing and the removal rate will decrease over time. Rubbing the polishing pad with a diamond abrasive disk removes this top glazed surface and uncovers fresh pad material for polishing. Proper conditioning parameters can lead to very stable removal rates.

Planarization – the removal of surface topology in a nanofabricated strucuture. This was original purpose of the CMP process. Planarization can be either just

local removal of step heights, called local planarization, or it can also be uniform removal of material across a die, called global planarization. CMP is currently the only planarization process that gives global planarization.

Polishing pad – a polymer pad that the wafer is rubbed against during the CMP process. It is applied to the polishing table which rotates under the polishing arm. Slurry is dispensed on to the pad and the polishing arm pushes the carrier head against the pad to polish the wafer. Polishing pads are designed with a variety of properties and purposes.

Post-CMP cleaning – CMP slurries contain abrasive particles to perform the mechanical removal of the surface material. These abrasive particles must be removed from the wafer surface after polishing to prevent defects. After CMP, the wafers must be kept wet prior to cleaning because once the slurry is allowed to dry on the wafer, it is very hard to get off mechanically. Due to electrostatic attraction forces though, simply rinsing the wafers with water after polishing will remove little if any of those particles. Modern production equipment use wafer brushcleaners to clean and dry the wafers after CMP. These tools use PVA brushes to mechanical wipe the surface of the wafer and remove the abrasive particles. Additionally, they use dilute ammonium hydroxide to reduce the electrostatic attraction of the slurry particles to the wafer surface. It is important for any CMP process to determine how you are going to clean the wafers when you are done.

PVA – polyvinylalcohol, a soft spongy hydrophilic polymer material used in post-CMP cleaning to mechanically remove slurry particles.

Quill – or Spindle. The motor on the polishing arm that rotates the carrier against the pad. It turns in the same direction as the polishing table.

Removal Rate – the average rate at which material is removed from the surface of the wafer. Most often reported with a uniformity value as measured on a unpatterned wafer.

Retaining ring – a hard polymer ring on the carrier head that surround the wafer when it is mounted on the carrier head. The top surface of the ring sits above the wafer backing plate by a set amount to form a recessed circular area called the pocket. The depth of the pocket is important for successful polishing.

Selectivity – a ratio of removal rates between two different materials for a given CMP process. This is often determined by measuring the average removal rates on blanket film wafers. As an example, for the polysilicon damascene process, the vendor states that the slurry, when used in a specific CMP process, gives a 300:1 selectivity between polysilicon and thermal oxide. The value reported by this method is often much higher than what is achieved on a patterned wafer due to erosion effects.

Shallow Trench Isolation (STI) – Device isolation process for CMOS that utilizes CMP to allow for tighter device spacing. First, a silicon oxide and nitride layer is put down on the wafer to protect the surface from CMP damage. The wafer is etched to leave the device areas raised as 'mesas' with a lower trench area surrounding it. An oxide is deposited over the wafer thick enough to fill the trenches above the height of the mesas. An oxide CMP process is then utilized to remove the oxide over the mesas to expose the active device areas. The silicon nitride layer acts as a stopping layer for the CMP process and protects the silicon from mechanical damage during CMP.

Slurry – a mixture of abrasive and chemicals used to perform CMP. It is continuously pumped on the polishing pad during the CMP process. Most slurries remove material through a combination of chemical and mechanical methods so they are generally material specific. A given slurry may be used to polish materials other than the material it was designed for but unwanted results may occur.

Spindle – or Quill. The motor on the polishing arm that rotates the carrier against the pad. It turns in the same direction as the polishing table.

Surface roughness – a measurement of the surface irregularities. Most often expressed as a root mean square (RMS) value of the height variation in angstroms. A given polishing process will give you a set surface roughness on the small scale, but if measured over large areas it will measure higher due to the microscratching that occurs.

Touch up polish – a quick, low removal polishing step optimized for scratch removal and low surface roughness. Utilized after a primary polishing step to improve the surface finish and reduce defect levels. This type of polish was developed due to the high defect levels from the tungsten damascene process. After the tungsten CMP step, an oxide touch up or buff step would be performed to improve the silicon oxide surface qualities.

Uniformity – a measurement of how uniform the removal rate is across the wafer. It can be measured many ways but the most common is the standard deviation (SD or σ) of the measured removal rate expressed as a percentage of the removal rate. It is also sometimes called a measurement of non-uniformity.

Wafer capture – the amount of the wafer that is in the pocket usually expressed as a percentage of the wafer thickness. The opposite of wafer extension.